



NASA STTR 2012 Phase I Solicitation

T12 Materials, Structures, Mechanical Systems and Manufacturing

Materials, Structures, Mechanical Systems, and Manufacturing This topic is extremely broad, covering five technology areas: materials, structures, mechanical systems, manufacturing, and cross-cutting technologies. The topic consists of enabling core disciplines and encompasses fundamental new capabilities that directly impact the increasingly stringent demands of NASA science and exploration missions.

Subtopics

T12.01 High Temperature Materials and Sensors for Propulsion Systems

Lead Center: GRC

Advanced high temperature materials and sensors are crosscutting technologies which can be used in component and subsystem applications essential in the design, development and health maintenance/detection needs of future generations of aeronautical and space propulsion systems. Proposals are sought that address:

- Advanced high temperature materials technologies, both design and development, needed to meet application challenges associated with propulsion systems. Proposals must be linked to improvements in future performance indicators, such as vehicle weight, fuel consumption, noise, lift, drag, durability, and emissions for aircraft, and/or reduced mass components and thermal management properties to meet space vehicle propulsion needs. Technology interests include:
 - Innovative approaches to enhance the durability, processability, performance and reliability of advanced materials (super alloys, high strength fibers and environmental barrier coatings for ceramic matrix composites with temperature capability greater than 2700 °F, and corrosion/oxidation resistant coatings for turbine disk materials operating at temperatures in excess of 1400 °F, innovative joining methodologies for bonding powder metallurgy disk material to directionally solidified/single crystal rim alloy for a hybrid disk);
 - High temperature shape memory alloys and methods to integrate these materials into propulsion system structures for changing component shape and actuation devices;
 - High temperature magnets with greater than 500 °F capability;

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- Multifunctional high temperature materials, combining structural properties with a second capability, such as power harvesting, thermal management, self-sensing, and materials for wireless sensing and actuation;
 - Environmentally-friendly manufacturing processes for high temperature polymer materials with temperature capability 500 °F or higher.
- Innovative smart sensing methods and associated measurement techniques for the cost-effective, reliable assessment of the health of aerospace engine and vehicle components in harsh high-temperature environments (1900 °F - 3000 °F) allowing a proactive approach to maintain capability and safety. Engine and vehicle structures ground and flight testing applications can lead to thermal and other environmental conditions beyond the limits of current sensing technology. Sensors and systems are required to have fast response, low volume and weight, be minimally intrusive and possess high accuracy and reliability. Special areas of interest include:
 - Development and validation of innovative sensors and improved methods for attaching to advanced high-temperature materials and integrating sensors into systems (wireless, wired or fiber optic).
 - Approaches to measure strain, temperature, heat flux, deflection, acoustics and/or acceleration of structural components are sought.
 - Compact, non-contact, full-field sensing systems for structural information.
 - Nanotechnology offers a means to: a. develop higher-temperature/environmentally-resistant structural materials with engineered micro structures that can optimize material properties for propulsion hot section components; b. enables tailoring the thermal conductivity of materials, making them more efficient conductors or insulators; c. permits targeted sensor applications that can improve functional efficiency; d. supports developing nano-sensors that may be incorporated in hot section structures/systems that are smaller, more energy efficient and potentially providing more sensitive health assessments capability.
 - Design Methods/Tools, which are robust and efficient, to design advanced materials based on first principles and micro structural models that can be used in a multi-scale framework.

Proposed Deliverable to NASA: Advanced high temperature materials, high strength fibers, protective coatings; new sensors, attachment techniques, beta versions of sensor systems; and new computational models.

What would be the major implication of not having this subtopic? High temperature materials technologies are required to meet the flight vehicle hot surface needs and to enable development of the advanced aerospace propulsion systems necessary to the NASA mission success. Industry looks to NASA to provide these technologies and capabilities to help them meet/exceed the National goals - environmental regulations, contributing to green energy and meeting and customer performance requirements. Novel sensor systems are critical to moving the technology from the laboratory environment to ground test activities and flight vehicle applications.

NASA Relevance: High temperature materials and advanced sensors were each highlighted as high priority needs in both the National Aeronautics Plan for Aeronautics Research and the National Research Council's report, NASA Space Technology Roadmaps and Priorities, documents.

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- Mobility R&D Goal 5 Far-term Objective 3
 - National Security and Homeland Defense R&D Goal 3 Far-term Objective 1 and Goal 4 Far-term Objective 2
 - Aviation Safety Goal 1 Far-term Objectives 1 and 3
 - Energy and Environment R&D Goal 2 Far-term Objective 2, 3 and 4

Space:

- Reduce vehicle mass and/or improve thermal management performance by employing nanotechnologies to develop lighter-weight multifunctional materials/ (structures) and sensors with unique capabilities and better performing.
- Structural health monitoring/sensors for long duration missions/responsive on-board systems:
 - Reduced propulsion structure mass.
 - Computational modeling design/analysis/simulation methods for materials certification/reliability.

Center relevance, i.e., project, program and mission:

- ARMD Programs.
- OCT.
- Space Exploration Mission Directorate.

List any commercialization plans or possible mission opportunities for technologies: Upcoming ARMD and reimbursable testing activities

Other potential government funding or applications:

- ARMD Seedling.
- Fundamental Aeronautics at higher TRL.
- OCT CIF.
- DOD.
- DOE.

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- DARPA.

Identify OCT Mission Directorate and/or Field Center advocate(s) committed to support development through a Phase III award:

- Leslie A. Greenbauer-Seng (GRC/Deputy Structures and Materials Division).
- Tim Risch (DRFC/Deputy Chief Aerostructures Branch).

T12.02 Materials and Manufacturing Technologies

Lead Center: MSFC

Participating Center(s): GRC, JSC, LaRC

NASA's science and exploration missions continue to seek materials and manufacturing techniques and capabilities that will allow missions of increased capability and reduced costs. These future missions depend highly on advancements such as lighter and stronger materials and manufacturing methods. Materials and manufacturing technologies have high value and make a significant contribution to the interests of others outside of NASA, specifically those that address broader national needs as well as the needs of the commercial space industry. The portfolio of advanced materials and manufacturing technologies is extremely broad and cross-cutting with complex interactions between core disciplines (e.g., materials and structures), applied R&D, innovation, and production.

In reference to the recent report from the National Research Council on the Space Technology Roadmaps produced by NASA's Office of Chief Technologist, the report ranks lightweight and Multifunctional Materials and Structures as an area of high priority development to be emphasized over the next 5 years. This topic seeks technologies that support these needs:

- Lightweight and multifunctional materials concepts including, advanced composite, metallic, and ceramic materials that significantly enhance future exploration and science missions and enable new missions.
- Digital/Model-based Manufacturing technologies that enable cost-effective manufacturing for reliable high-performance structures and made in low-unit production, including in-space manufacturing.
- In-space and additive manufacturing that offers the potential for game-changing weight savings and new mission opportunities.

University researchers are well-positioned to make a positive contribution within the time and funding allocation vis-a-vis a concept demonstration, enhancement of an existing component through a clever innovation, working prototype, etc. Also, this topic of materials and manufacturing technologies supports and is closely aligned with the President's National Strategic Plan for Advanced Manufacturing.

